TABLE 21. AREAS WITH SPECIAL MANAGEMENT RESTRICTIONS

Area Description	Restrictions
Islands 58 acres	No management
Steep Slopes	No management
Wetlands 1,630 acres	No management except limited beaver control (see beaver policy)
Rare and endangered species habitats 3,164 acres (includes reservoir surface)	Subject to restrictions by MassWildlife/NHESP
Riparian zones adjacent to tributaries and the Reservoir shore 576 acres	Subject to restrictions of FCPA (Ch. 132); limited non-harvest silviculture
Poutwater Pond Nature Preserve 213 acres	Restricted according to The 1997 MDC Protection Plan for Poutwater Pond Nature Preserve
Disturbance-sheltered areas	Relatively low intensity management
Areas of Historic, Cultural or Natural Significance	Varies from no management to selective restoration and management
Primitive Woodlands	Yet to be determined

5.2 Management of Forested Lands

5.2.1 Description of Forest Management Approach for 2001 – 2010

5.2.1.1 Objectives of Wachusett Forest Management

The primary goal of management of the Wachusett forest is the creation of a forest that best supports the production of high quality drinking water from the land. This watershed protection forest is vigorous, diverse in species and ages, actively accumulating biomass, and actively regenerating.

The first forest management plan for any DWM property, written in 1960 for the Quabbin forest, proposed that a predominantly uneven-aged forest provides the best protection for a high quality water supply. Every Quabbin plan since then has agreed with this statement including the latest 1995 – 2004 plan. This first Wachusett Plan continues this tradition with a conviction based on the most up-to-date information, the latest review of relevant information and literature, and the experience of the professional staff in the management of the Wachusett forest.

The conversion of the present even-aged forest to a forest comprised of at least three age classes has already begun, although at a slower pace than is now required, given the significant increase in acreage resulting from the land acquisition program. When the forestry program began in 1979, the MDC owned approximately 5,600 acres in the watershed compared to the 16,822 acres owned as of the writing of this plan. The creation of three well-defined age classes in any section of the forest necessitates that one-third of the forest be regenerated to a new age class followed by the creation of another age class some appropriate length of time later. This length of time will be about 20 to 30 years, a sufficient span

of time to allow the various age classes to grow and thereby be well differentiated from each other. The principal goal for the next 30 years will be the establishment of a new age class on approximately one-third of the 12,000 acres of manageable forest on MDC land at Wachusett.

A silvicultural system is defined as, "…a planned program of silvicultural treatments during the whole life of the stand." (Smith 1986) The name of the system is commonly derived from the name of the reproduction method that is used to regenerate the stand. The silvicultural system that will be employed throughout the vast majority of the Wachusett forest in order to create three distinct age classes, is a variation of an uneven-aged system. The silvicultural method that perhaps best describes the regeneration plan for the Wachusett forest is group-selection or uneven-aged with patch cutting as suggested by Marquis (1991). However, the tendency to pigeonhole a complicated and highly variable process into a pre-defined term can unnecessarily restrict the wide variety of techniques available to forest managers. "Formulation of a silvicultural system should start with analysis of the natural and socioeconomic factors of the situation. A solution is then devised…When the important act of inventing the solution has proceeded far enough the less important step of attaching a name to it can be taken." (Smith 1996)

Over the next 30 years, one-third, or 4,000 acres of the managed forest at Wachusett will be converted to a new age-class. For this age class to be evenly distributed throughout MDC land and evenly spaced through time, 130 acres must be regenerated each year. Therefore, approximately 400 acres will be treated annually (one third of which is regenerated).

5.2.1.2 The Role of Natural Disturbances at Wachusett

Natural disturbances occur at virtually all scales of time and area. The infestation of a single tree by carpenter ants, the perpetual browsing of deer, and a forest fire are all natural disturbances. These disturbances, though "natural," can compromise the ability of our forest to protect water quality. It is the goal of DWM to insure the supply of high quality drinking water for both the short and long term. The management of the Wachusett forest must be planned to mitigate any negative impact resulting from natural disturbances, both large and small scale. The most significant disturbance that effects the forests of Massachusetts is hurricanes.

> From meteorological records and forest reconstruction it has been estimated that hurricanes strike southern and central New England every 20-40 years, while catastrophic storms like those of 1635, 1788, 1815 and 1938 occur approximately every 100-150 years. (Foster 1988)

Catastrophic hurricanes have the ability to disturb a significant portion of the forest, changing species composition and age distributions suddenly. However, there are variables that effect the extent to which a forest is impacted by various windstorms and some of these are under the forester's control. A study of the Hurricane of 1938 at Harvard Forest in Petersham, MA (Foster and Boose, 1992) shows that conifers are more susceptible to windthrow than hardwoods and tall trees are more susceptible than short trees. These two factors in combination with the slope and aspect of any given site are significant determinants of wind damage. In the Harvard study, conifers greater than 34 feet tall and hardwoods greater than 74 feet tall on nearly level sites (<5 degrees) or windward oriented slopes (S,SE,E) were severely damaged (>75% of all trees were damaged); there was intermediate damage (50-75% of all trees were damaged) on mild leeward slopes (5-10 degrees, N,NW,W) or intermediate orientation (NE,SW, >5 degrees). Hardwoods greater than 64 feet tall on these same exposures were damaged 51-75% and 25-50% respectively.

The structure of an uneven-aged forest, with three age classes well distributed across the landscape, is well designed to both resist and recover from the impacts of windstorms. Resistance is improved when much of the forest is shorter than the critical height categories according to the Harvard model and resilience is improved when there are enough young trees in place to reoccupy the site should the overstory be destroyed. This structure should translate to less risk to water quality in the event of a major windstorm. Fewer trees blown over means fewer trees needing to be salvaged and reduced fire hazard, and therefore a lower risk of subsequent nutrient losses to tributaries and the reservoir.

5.2.1.3 Forest Insects and Diseases

Damaging insects and disease causing organisms are as normal and natural a part of the forest ecosystem as are the trees themselves. To view these organisms as nothing more than destructive agents whose absence would only benefit forest health is to misunderstand their ecological role. They not only are vital components of biological diversity but play key roles in numerous ecological functions including nutrient cycling, decomposition and predator-prey relationships. The impact of an infestation or disease outbreak can only be viewed from within the context of management objectives. A homeowner, whose front-yard specimen birch tree is infested by the bronze birch borer, is justified in viewing the situation as serious and worthy of immediate action. The death of this tree would conflict with the objective of having a healthy attractive birch in the yard. A single infested tree in the middle of the forest is not a concern where the objective is to have a healthy, functioning forest ecosystem. In fact, having trees dying in the forest is a necessary aspect of a healthy forest.

In the Wachusett forest, insects and disease are a major problem only when their impacts conflict with the Division's objective of creating and maintaining a watershed protection forest. For the most part, this means that only large-scale outbreaks that threaten to alter tree species diversity or forest structure fall into this category. Chestnut blight was such a disease. It was first discovered in the Wachusett forest in 1911 and had already spread to chestnut trees in all towns of the watershed. Salvage of the dead and dying trees began immediately in the hope of protecting the yet uninfected chestnuts. Before the blight, chestnut was one of the dominant trees in the forest. Today, it is essentially a minor shrub. Occasionally, an individual may grow to the status of a small tree before again being infected, dying back to the ground and perhaps putting out new sprouts.

The gypsy moth is another example of a serious pest. It was first found in the Wachusett forest in 1910. A great deal of effort was spent in trying to control the inexorable spread of this insect. Every winter, all egg masses that could be found were painted with creosote. The Annual Report for 1916 states, "At the close of the year about 2,000 acres of land had been covered and 143,100 egg clusters had been found and painted at a cost of $818." This work continued at least until 1947 when the last Annual Report was written. Epidemics of this insect can result in significant mortality of a wide range of tree species both in the overstory and understory resulting in alterations to forest structure, composition and health.

MDC archive

Gypsy moth caterpillar

Both the fungus that causes chestnut blight (*Cryphonectria parasitica*) and the gypsy moth (*Lymantria dispar*) are introduced organisms that came to the Wachusett forest without their co-evolved complement of predators and parasites; a recipe for the development of an unhealthy ecological condition. Other examples that have in the past or currently effected the Wachusett forest include Dutch elm disease, beech bark disease, and white pine blister rust. Native species generally remain in balance with their predators except when cultural effects (past land use or deliberate forest management) create unusual

conditions. Some examples are establishing species that are unsuited to the site, deliberately creating single species stands (i.e. plantations), and growing forests on soils that are nutrient depleted from a long history of farming practices.

The next significant threat to the Wachusett forest is the hemlock woolly adelgid (*Aldeges tsugae*), a small aphid like insect native to Asia, first seen in the eastern U.S. in Virginia in 1955. Since then it has been moving up the East Coast and was first found on the Wachusett watershed in 1998 in Boylston. It feeds on hemlock at the base of the needles, removing nutrients and secreting a toxic substance in its saliva. The most recent research and observations indicate that the amount of hemlock in the forests of Massachusetts may be significantly reduced over the next decade or more. While hemlock comprises just 2% of the stocking of the Wachusett forest, a significant proportion of it occurs in riparian zones and on steep slopes above riparian areas. This makes the loss of these hemlocks potentially more critical from a water quality point of view and the commercial salvage of these areas more problematic. No extraordinary measures will be taken to salvage infested hemlock on upland sites. However, sites deemed more critical to water quality will be considered for salvage operations either through commercial or non-harvest means.

T. Kyker-Snowman

Egg casings of hemlock woolly adelgid

5.2.1.4 Species/Site Suitability

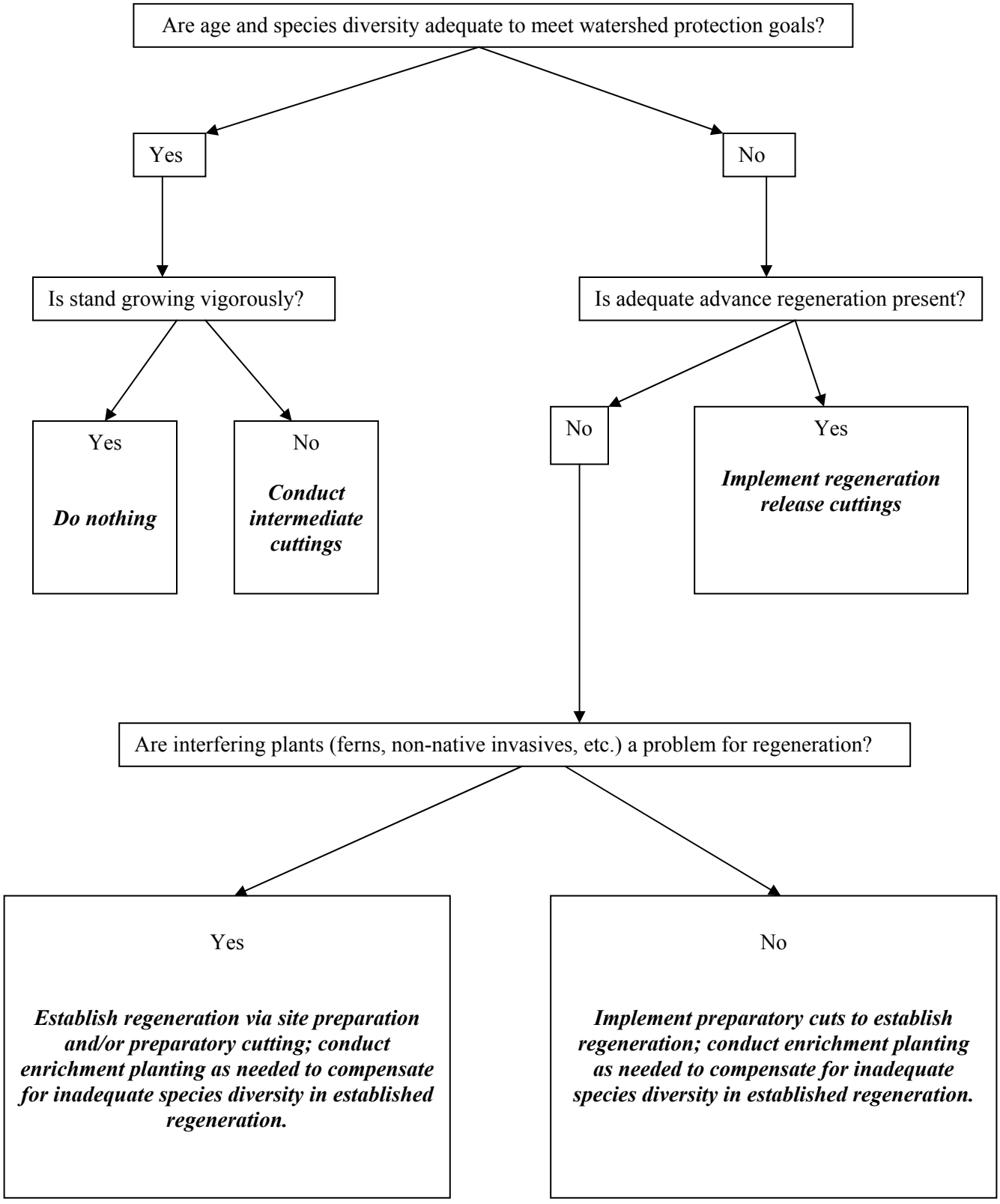
Every species of tree has a preferred range of environmental variables that best suits its long-term health and reproduction. These variables include the amount of light received, heat (i.e., minimum and maximum seasonal temperature) and soil nutrients and moisture. Much of the Wachusett forest owes its composition to three factors: succession following past land use practices (especially pastures and agriculture), succession following the Hurricane of 1938, and the deliberate planting of both conifer and hardwood species. None of these three modes of stand initiation guarantees that the species that occupy the site are those that are best suited to that site or that the diversity of species is adequate. Many white pine plantations were established on moderately well drained soils that are far better suited to the long-term growth of a variety of hardwood species such as red oak and sugar maple. Conversely, past land use practices and fire history have resulted in stands of white, black and scarlet oaks on excessively drained sites where white pine is well suited and should be a major component. It is a primary goal of forest management in the Wachusett forest to encourage the development of stands of trees comprised of species well suited to the site. This is a critical factor in our larger goal of creating a healthy, stable, low maintenance forest.

5.2.1.5 Silvicultural Practices

Figure 5 outlines the general decision-making process Division Foresters follow to determine the appropriate silviculture for any area. At its most basic, the process can be simplified to the following:

- Where regeneration is lacking, we will establish it.
- Where regeneration is adequate, we will release it.
- We will encourage species appropriate to the site.
- Most importantly, we will cut the poorest quality trees first and leave the best.

FIGURE 5. SILVICULTURAL DECISION-MAKING PROCESS



5.2.1.5.1 Establishment of Regeneration: Preparatory Cutting and Planting

There is no hard and fast rule for determining whether or not an existing level of regeneration is adequate. There are three factors to consider when making such a determination: the species composition/site suitability, the number of seedlings/saplings, and the spatial arrangement. A high number of seedlings well distributed but of a species poorly suited to the site is considered inadequate. Conversely, a patchy distribution of a variety of species well suited to the site may be adequate if it occupies enough of the area to warrant release as a new age class. In the MDC's 1991 Quabbin Reservation Deer Impact Management Plan (MDC, 1991), an exhaustive literature review and a survey of regeneration in "off-Reservation" lands at the Quabbin were performed in order to determine what "success" meant regarding the level of regeneration following deer population control efforts. Adequate regeneration was defined as the establishment of at least 2,000 stems per acre of seedlings/saplings greater than 4.5 feet in height of a diverse species distribution. Spatial arrangement, the distribution of regeneration across the forest, is an additional objective of regeneration adequacy.

On sites where the level of regeneration is considered inadequate, preparatory cuttings will be prescribed. These are designed to open the canopy sufficiently to allow increased light and heat levels at the forest floor thereby stimulating seed germination and seedling development. At the same time, the species composition of the overstory, and therefore the makeup of the seed sources, can be adjusted, disturbing the leaf litter can enhance the seedbed, and competing vegetation can be reduced.

In situations where a desired species is absent from the overstory and therefore a seed source is unavailable, planting will be considered. The most common examples of this situation are dry site mixed oak stands with no white pine component in the overstory. The only practical method to establish white pine in these stands is through planting.

5.2.1.5.2 Release of Regeneration

Once adequate regeneration is in place, it will be released systematically to give it light and space to grow. This is accomplished by harvesting a portion of the overstory from designated stands. The cutting cycle (the period between harvests) for any given area will average 20 to as long as 30 years, depending on the site. Most areas will be treated using a variation of the selection method as previously described. Trees will be removed either singly or more often in groups and patches ranging from ¼ acre to two acres in size, with an average of about 1 acre. This range in opening size allows for the successful regeneration of a wide diversity of species due to varying tolerances of shade. It is anticipated that openings larger than one acre will become increasingly rare as the forest is brought into a more balanced distribution of ages, sizes, and species than currently exists.

T. Kyker-Snowman

Regeneration release opening

Occasionally, there is the need to take a more wholesale approach to the conversion of stands comprised of species poorly suited to the site or unstable stands of damaged, low-vigor trees. Overstory removals larger than 2 acres are an option under the following situations:

- *Plantations*. The most common examples are the plantations (most comprised of red or white pine and Norway or white spruce). Some of these plantations were never thinned and consequently the trees are tightly spaced with short, narrow crowns. These stands are poor candidates for small openings or partial overstory removal due the poor form and inadequate wind-firmness of the residual trees. The most practical method for regenerating these stands is the removal of larger blocks of overstory trees following the establishment of regeneration. Regeneration may be established in these stands either through the very careful application of a preparatory operation (the creation of strips within the plantation or overstory removal immediately adjacent to the plantation) or through planting.

- *Degraded stands*. Also common are stands of very low quality and vigor. These stands typically result from high-grading (the highest value trees removed, leaving only poor quality trees) and/or poor harvesting (excessive damage to residual trees, incomplete removal of poorly-formed or diseased trees) by previous landowners. Regardless of the cause, the result is high-risk stands of low quality, low vigor, and often physically damaged trees. An overstory comprised of such trees is not a viable long-term protection forest. These stands often have diverse advanced regeneration that is ready to be released. Removal of large blocks of overstory trees is the most desirable method for restoring these stands.

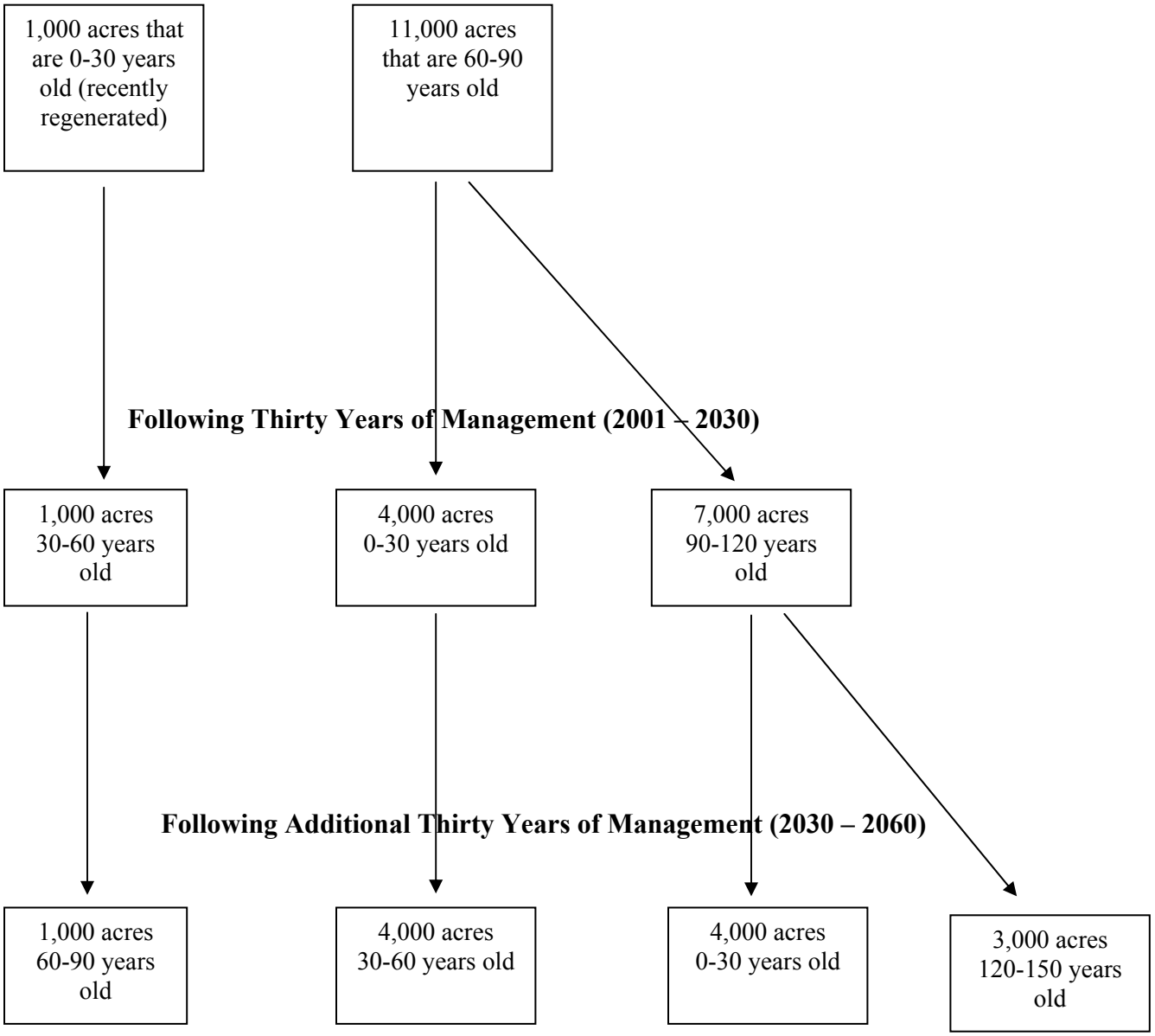
In order that an adequate accounting be kept and to insure that each regeneration cut leads to the desired result, the acreage of the area that is released to a new age class for each silvicultural operation will be recorded. In this way, the long-term impacts of management will be assessed as well as the immediate impact on the distribution of age classes within the stand, sub-basin and forest. The Division will contract a photographic fly-over of MDC property mid-way through each ten-year management plan period. This will greatly enhance the ability to document and monitor the progress of this gradual conversion of the forest. Figure 6 depicts the generalized, long-term silvicultural strategy for converting the current even-aged forest to one composed of balanced distributions of three age classes.

T. Kyker-Snowman

Feller-processor in spruce plantation

FIGURE 6. CHANGES IN WACHUSETT FOREST AGE STRUCTURE VIA SILVICULTURE: 2001-2060

Current Structure of the Managed Forest (2001):



5.2.1.5.3 Intermediate Cuttings

Intermediate cuttings are performed on stands prior to maturity. They are designated as "thinnings" when the objective is to remove trees of low vigor thereby decreasing competition within the stand and increasing the vigor and growth rate of the remaining trees. "Improvement" operations are designed to adjust the species and quality composition of stand. In fact, virtually all intermediate cuttings are a combination of both thinning and improvement. The defining characteristic of all intermediate operations is that there is no intention regarding the establishment or encouragement of regeneration.

In the Wachusett forest, intermediate cuttings are rarely performed as the sole objective. This is due to the relative lack of purely pole-sized stands on MDC property, although this is changing as land is acquired that has a different forest management history than the bulk of the MDC-owned forest. Most intermediate operations are performed simultaneously with preparatory and regeneration cuts as many stands are being treated for the first time without the benefit of prior management. During the next ten years, intermediate cuttings are planned for 100 acres.

5.2.1.5.4 Non-Harvest Silviculture on Sensitive Sites

There are areas across the watershed where adding new age-classes in order to improve resilience is a high priority but conditions do not allow commercial operations. Examples include steep slopes and areas where soils will not support conventional machinery. On a limited area of less than 100 acres, overstory manipulations will be conducted in some of these areas without removing forest products. MDC will select only those sensitive areas where there is a clear threat of loss of overstory and where this event would have a significant effect on a tributary or shoreline area. Examples include pine plantations with restricted access, high hurricane exposure and shore frontage.

The technique would remove the minimum amount of overstory to allow understory development of either native regeneration or planted trees. Efforts would be made to fell trees across the slope, and to lop the branches to reduce fire danger. This method has the advantage over natural disturbance of methodically selecting both the timing and the placement of openings, which then fill with younger age classes and "anchor" the area in the event of a major overstory disturbance. As the trees will not be removed, there will be negligible risks of soil disturbance or erosion in these areas.

5.2.1.5.5 Riparian Zone Management

The most common riparian zone management strategy land managers take in a variety of plans and Conservation Management Practices is simply to leave these areas alone. In fact, this strategy has the force of law in many states, as a component of wetland protection or timber harvesting regulations. MGL Ch. 131 (Wetlands Protection Act) and Ch. 132 (Forest Cutting Practices Act) both contain language that restricts activities within riparian zones. The assumption behind these regulations is that manipulations of these zones will degrade the critical buffering capacity of these areas and may result in soil disturbances that are more likely to result in sediment transport into streams. However, studies show that it is the activity of removing trees that is associated with these impacts. The MDC/DWM recognizes these zones as the final, and therefore most critical opportunity to slow or capture nutrients and sediments released by a variety of natural and man-caused events on the watersheds.

Section 3.2 includes a review of literature regarding the benefits of establishing forested buffers along streams in urbanized watersheds. While urbanization increases flood flows and the concentration of a number of pollutants in stormwater, forested buffers help to filter these pollutants before they reach streams. Depending upon the size of the forested area, these buffers may reduce flood flows (Anacostia Restoration Team 1992, Neville pers comm. 1996, Lowrance 1994, Schueler 1987, USDA Forest Service 1991, and U.S. EPA 1993). Forested buffers also have the benefit of discouraging geese from grazing and loafing on the reservoir shoreline and have been recommended by the recently completed Watershed Protection Plan for Sudbury watershed as an effective practice for this reason (Comprehensive Environmental 1997).

C. Read

Riparian zone

Section 3.2 recommends that MDC become more active in assisting private landowners in establishing a forested buffer along streams. While most MDC riparian lands are already forested, additional protection can be gained by enhancing the structure and composition of riparian forests and by reducing shoreline and streamside mowing practices.

The preferred vegetative structure of riparian zones is an actively growing, diverse, self-perpetuating, and disturbance-resistant forest cover. While this is the objective for the majority of MDC watershed land, it is more critical at Wachusett and is therefore a very high management priority. Maintaining this forest structure throughout the variety of disturbances that impact all New England forests, including riparian zones, may be best accomplished through carefully planned and implemented human intervention. To some degree, being located within the bottom of stream and river valleys shelters riparian forests from wind damage. However, as these forests mature, and especially where they are in the path of prevailing storms, they become vulnerable to sudden and dramatic damage. When this damage occurs, it is of great concern to watershed managers because it can result in substantial amounts of soil and nutrient transport. Addition concerns include sudden changes in stream temperatures due to the loss of forest cover and heavy accumulations of woody debris when trees fall directly into the stream channel.

As is true for maintaining the watershed forest in general, the most important resistance to build into these forests is the establishment of regeneration. This regeneration serves to anchor soils following disturbances, resists damage from many disturbances (due to size and density), and shortens recovery times for reestablishing riparian forests following disturbances.

Riparian forests that are simply left alone will establish regeneration as the overstory begins to age and decline in vigor. However, where full crown closure is maintained for long periods of time, understory development will be limited by low understory light and thus there will be delays in recovery following major disturbances. Through carefully implemented manipulations of the overstory and understory, MDC managers intend to systematically "condition" certain vulnerable riparian forests to be better able to fulfill their critical buffering functions throughout significant disturbances. Specific management strategies, and the types of riparian zones to which they will be applied:

- Standard silvicultural removals will occur within the managed forest where soils and cutting practices allow (Section 5.2 and Figure 5.)

- Directional felling of small groups and individual trees, without removal, will be done to bring light to the understory where soils prevent equipment of any size. Trees will be felled perpendicular to

prevailing slopes and cut into sections so that the trunk comes in contact with the ground to enhance the sediment trapping capabilities of the riparian zone. Felling will not be done into streams. It is felt that natural fall due to individual tree death (as opposed to catastrophic events) will add sufficient material in streams to create beneficial debris dams.

- Planting will occur in areas where seed source is limited, where herbaceous competition is significant, where protective ground cover is currently lacking (e.g., under dense plantations), and where aesthetics is a concern (e.g., near residences or high use areas). This practice may include planting with "tree tubes" sufficiently tall to bring seedlings above herbaceous cover. It will also include non-harvest fellings in order to maintain light levels sufficient to support understory growth.

As this is a new approach to watershed management, it will consist chiefly of directional fellings and tree plantings. The areas chosen are:

- Areas where an important buffer or riparian area is involved.
- An area that is exposed to significant disturbance, such as from future hurricanes.
- An area that would benefit from planting and tubing to help establish regeneration.

5.2.1.5.6 Salvage Policy

The advancing average age of the Wachusett watershed forest and the steady arrival of new insect pests have lead to an increase in salvage cuttings in recent decades, in response to natural disturbances. In addition to (or shortly following) insect and disease damage, these disturbances include windthrow, especially of trees with weakened root structures, and ice and snow damage. Salvage activities are not planned, but are important components of watershed maintenance when the disturbance damages large areas of forest, or greatly increases the threat of additional damage. Removals of dead or dying trees from damaged forests can lower fire hazard (e.g., in hemlock defoliated by looper or woolly adelgid), allow the salvaging of timber value, and strengthen the resistance of surviving trees (e.g., by removing trees weakened by gypsy moth to improve survival of adjacent trees). The Division is aware of the importance of the steady addition of large woody debris to the forest ecosystem. However, the volume of dead and dying wood that is eventually salvaged is a small fraction of the total mortality in any given period of time. Therefore, ecosystem functions will continue to be met while other short-term concerns are addressed.

Where large areas are involved, salvage activities may preempt planned activities described in this plan. Following the microburst tornado that struck the watershed in 1989 (and damaged 300 acres of MDC forest in less than 20 minutes), there was strong public pressure to "clean up the mess." The close proximity of these watershed forests to residential developments may increase the priority for salvage following disturbances, to improve aesthetics and reduce both perceived and actual fire danger. In addition to public pressure for a rapid response, there are often other time pressures driving salvage operations. For example, when white pine is damaged during the warm months of the year, its wood loses value rapidly due to fungal invasions that cause discoloration ("blue-stain"). Wood-boring insects also invade damaged timber rapidly during warmer months and can greatly reduce value. Where roads are blocked by disturbances in adjacent forests, there is also an obvious need to conduct salvage rapidly in order to restore access, which is critical for fire control and emergency response. In situations that involve these time pressures, review and timber harvest permit procedures may be streamlined when an operation is deemed to be salvage and conditions warrant rapid action.

5.2.1.6 Summary of Planned Silvicultural Activities

To summarize the above sections describing the activities that are planned to meet forest management goals, the Division plans to complete the following silvicultural activities during the period from 2001-2010:

TABLE 22. PLANNED SILVICULTURAL ACTIVITY, 2001-2010

Operation	Estimated Amount
Pine Plantation Intermediate and Regeneration Cuttings	650 acres
Non-Plantation Intermediate Cuttings	100 acres
Non-Plantation Preparatory and Regeneration Cuttings	3,250 acres
Areas of Non-Harvest Silviculture	100 acres
Tree Planting	30,000 trees on 300 acres

As the land acquisition program has vastly increased MDC landholdings throughout the watershed during the past decade, it became necessary to reorganize the basis upon which forest management activities are organized and tracked. In the past, Compartments were the basic level of organization. Roads and streams arbitrarily defined compartments and an attempt was made to make them all roughly the same size. In an effort to more closely tie management priorities to the basic hydrologic sub-unit of the watershed, all forest management activities are currently organized at the sub-basin level. This gives management decisions a stronger basis from a hydrologic point of view and allows better coordination between watershed protection priorities and forest management priorities.

5.2.1.7 Silviculture by Major Forest Type

The major forest types are described below with a summary explanation of the silviculture that is planned for each type.

5.2.1.7.1 Oak Type

The oak type is best divided into two sub-types based on site characteristics.

5.2.1.7.1.1 Dry Site Oak Type

Scarlet, black, and white oak are the primary species along with red and chestnut oak, white pine and red maple. This type occupies approximately 1,910 acres, typically on excessively drained outwash soils and thin-to-bedrock till soils. Most of these forests owe their composition to a combination of past heavy cutting practices, fire history and the loss of American chestnut. These stands are typically of low vigor with slow growth rates, lacking in adequate regeneration and are the stereotypical "hotspot" where gypsy moth infestations arise.

The primary goal of management in these stands is the introduction of white pine as a component. White pine is far better suited to these sites. It is capable of superior growth than the oaks and regenerates well. There are stands where white pine exists as a scattered co-dominant, and sometimes dominant member of the overstory. These trees are highly valued as a seed source for future pine regeneration and their ability to function in this role is enhanced by removing competing trees from around them while creating a desirable seed bed throughout the stand by partial overstory removal. Where white pine does

not exist as a seed source, planting is a commonly used option and has shown good results. Pitch pine will be considered for introduction (it presently exists but sporadically and in very low numbers) into the very driest site where it is especially well adapted.

5.2.1.7.1.2 Mesic Site Oak Type

These stands, which occupy approximately 1,940 acres, are comprised of red, black and white oak with the hickories, red maple, black birch, and white pine as the most common secondary components. They are similar in origin to the dry site oak type but differ due to their occurrence on more mesic, moderately-drained sites. These stands will be converted to a greater diversity of species especially white pine and the longer-lived hardwoods such as hickory. The oaks, which are prime examples of the long-lived, low maintenance species that are sought for the watershed forest, will be maintained as a significant component.

5.2.1.7.2 White Pine Type

This type will be broken into sub-types based on stand origins. Those stands will only be considered plantations that are still predominantly composed of pine. Many stands that originated as plantations now have a significant component of hardwoods and will be included in the discussion of natural white pine stands.

5.2.1.7.2.1 Plantations

The only definitive character of the sites occupied by white pine plantations is that there is no pattern. Plantations were established on 1,045 acres on virtually every soil type from xeric outwash soils to poorly drained tills. Unfortunately, the one common factor is that until the 1980's, these stands did not receive the thinning operations that planting at a six by six foot spacing necessitates. The result is that there are now 380 acres of white pine plantation whose makeup is incongruous with those of a proper protection forest.

The goal of management for all of the plantations regardless of soil type is the conversion to an appropriate diversity of species. On the moister sites, this will lead to white pine being resigned to a minor component in the long-term. On the drier sites, white pine will be maintained as a significant component.

5.2.1.7.2.2 Natural White Pine Type

Natural stands that are composed primarily of white pine most commonly originate in abandoned fields and pastures. There is currently 620 acres of this type. The pine's relatively heavy seed is capable of falling through thick grass, unlike the lighter-seeded hardwoods. The result is stands of nearly pure white pine typically surrounded by stonewall. Pine that develops under these conditions are commonly attacked by the white pine weevil resulting in crooked, multiple leader stems. Such trees are more susceptible to wind and snow damage. Also, such stands are often heavily stocked with very limited understory development. Therefore, the goal of management is to diversify the species composition, introduce new age classes and remove the individuals of poorest growth form.

5.2.1.7.3 Red Pine Type

All of the red pine in the Wachusett forest was established by planting during the last century. Today, there are approximately 146 acres of red pine plantation. As was the case with white pine plantation, red pine was planted on a wide variety of soil types, many that are not well suited to the long-term development and regeneration of red pine. Red pine will grow very well on the moister, more fertile sites. However, it is also highly prone to root damage and subsequent disease problems and windthrow on these sites. Red pine is well suited to growth and development on drier soils and it is on these sites that a component of red pine will be maintained while encouraging an increased diversity of appropriate species. On the more mesic sites, red pine will gradually be eliminated as a component of the stands.

5.2.1.7.4 Mixed Hardwoods

There are approximately 1,320 acres of forest comprised of a variety of hardwood species. Red maple, white ash, hickory and red oak are the dominant species along with a component of white pine. This type is most common on mesic soils in mid- to low-slope situations and tends to grade into the red maple type as soil moisture increases. These sites are ideally suited to the growth of highly diverse stands. The focus of management will be the maintenance of this diversity, along with the establishment of new age classes.

5.2.1.7.5 Red Maple

Stands dominated by red maple occupy approximately 1,150 acres. Common secondary species include white pine, white ash, hemlock, red oak and black cherry. While most red maple stands occupy poorly drained, wetland sites, approximately 350 acres occur on non-wetland soils on low-slope sites that do support logging equipment given the use of adequate CMPs. Many of these stands are similar to mixed-hardwood stands except for the predominance of red maple, which often tends to be of poor form and vigor. Therefore, the goal of management will be the diversification of these stands at both the species and age class level. A greater component of species such as red oak, white ash, black cherry, yellow birch and bitternut hickory will be sought.

5.2.2 Conservation Management Practices for Watershed Forest Management

NOTE: MDC/DWM has begun to use the Canadian term "Conservation Management Practices" to replace the older term "Best Management Practices." Both terms refer to efforts to create resource-protecting standards for management activities.

Forest management at Wachusett is done to improve watershed protection. As a minimum Conservation Management Practice, the Division will uphold the standard that no measurable negative impact on the quality of water, as measured at locations downstream from a logging project, will occur. Division staff will measure water quality periodically upstream and downstream from logging projects to assure compliance with this standard. Described below are the specific practices designed to accomplish this compliance. It should be noted that the Division meets or exceeds the requirements of both the Forest

Cutting Practices Act and the Wetlands Protection Act (MGL Ch. 132 and 131). Whenever these regulations are revised, Divisions management practices will meet or exceed the revised standards.

5.2.2.1 Introduction

Strict adherence to MDC/DWM's Conservation Management Practices (CMPs) ensures that forest management is conducted in a manner that does not impair water resources or other natural/cultural resources on the watersheds. Silvicultural practices, as described in the management plan, are employed to bring about specific forest conditions. These practices require the cutting and removal of overstory trees to diversify structural and species compositions and to maintain the vigor of the residual overstory. The forest is treated, on an average, every 25-30 years and at that time, 1/3 or more of a stand may be removed to establish and release forest regeneration. The process of removing trees can impact the forest and soils essential to water quality if not carefully regulated.

Among the areas of greatest concern are the placement of forwarder and skid roads and log landings, where logging work is concentrated. Proper location of these in relation to streams, rivers, reservoirs, ponds, vernal pools, and bordering vegetated wetlands is important so that soils do not move from these areas into water or wetland resources. Beyond this principal concern, Conservation Management Practices are designed to diminish the negative impact of silvicultural operations on the residual vegetation, to minimize soil compaction during these operations, and to keep potential pollutants out of the water resource.

5.2.2.2 Variables

There are many variables to consider when planning and conducting a logging operation, including equipment limitations, weather, soil depth, soil moisture, topography, silvicultural practices, vegetation, and operator workmanship. Variables such as weather, soil moisture, soil depth, topography, and existing vegetation are beyond human control. The constraints they place on logging must be factored into planning, and logging schedules and expectations adjusted accordingly. Variables such as equipment, silvicultural planning, and operator workmanship can be modified, for instance by matching allowable logging equipment with the constraints of a given site.

5.2.2.3 Logging Equipment

Logging equipment has changed dramatically in the 30 years that forest management has been active on MDC watersheds,. The primary logging machine was once the 50-70 horsepower (hp) crawler tractor-sled combination. These tracked machines were 5-6' wide and weighed 5-7 tons. Today, most logging is done with a 4-wheel drive articulated skidders or forwarders with 70-100 hp, widths of 7-8', and weights of 6-8 tons. Skidders drag logs attached to a rear-mounted cable and winch, while forwarders carry logs on an integrated trailer.

Other types of logging equipment include grapple skidders, wheeled and tracked feller-bunchers, and feller-processors. A grapple is an add-on feature that replaces the winch and cable with hydraulically operated grapple arms. Feller-bunchers cut trees and put them in piles, usually for removal by a grapple skidder. There are 3 or 4 wheel feller-bunchers that must drive up to each tree for felling, whereas tracked models can fell a tree 10-20 feet from the machine. A feller-processor (usually on tracks) fells, de-limbs, and cuts trees, leaving piles of logs or cordwood, which are retrieved by forwarders.

Small skidders are useful for logging on watersheds whereas larger 100-130 hp models, that weigh between 8-11 tons and are 8-9' wide, are usually too large and heavy for stand and soil conditions. Combinations of small, maneuverable feller-bunchers and forwarders, small skidders and forwarders, and small tracked feller-processors and forwarders have all worked successfully on MDC watersheds. Table 23 shows typical combinations of equipment that work on various types of harvesting operations on MDC watersheds.

TABLE 23. HARVESTING METHODS/EQUIPMENT USED ON MDC WATERSHED LANDS, LISTED BY MOST FREQUENTLY HARVESTED PRODUCTS

Method/Equipment	4-8' Cordwood or pulpwood	8-20' Sawlogs, fuelwood, pulpwood	Whole-tree
1. Chainsaw felling with 4WD pickup truck	√		
2. Chainsaw felling with cable skidding	√	√	
3. Chainsaw felling with forwarding	√	√	
4. Rubber-tired, four-wheeled feller/buncher with grapple skidding		√	√
5. Rubber-tired, four-wheeled feller/buncher with chainsaw limbing and forwarding		√	√
6. Rubber-tired, three-wheeled feller/buncher with grapple skidding			√
7. Tracked feller/buncher with grapple skidding		√	√
8. Tracked feller/processor with forwarding	√	√	

In an effort to specify equipment that is appropriate on specific soils and within specific forest types, the Division has determined ground pressure and width measurements for most of the equipment common to the area, and specifies restrictions, where needed, in timber harvesting contracts. Widths are either from direct measurement or from manufacturer's specifications; ground pressures are based upon a formula that combines machine weight and weight of an average load of logs with an estimated footprint for the tire size specified, at an average tire inflation pressure. Examples from this rating system are listed in Table 24.

T. Kyker-Snowman

Forwarder with tracks

T. Kyker-Snowman

Rubber-tired skidder

TABLE 24. SAMPLE EQUIPMENT SIZE/GROUND PRESSURE RATINGS

Machine Model	Tires	Width	Ground Pressure
TimberJack 208	23.1 x 26	102”	4.9lbs/sq in
JohnDeere 440C	23.1 x 26	102”	5.0 “
Franklin 105XL	23.1 x 26	110”	5.3 “
TreeFarmer C4	18.4 x 26	93”	6.5 “
JohnDeere 540	23.1 x 26	105”	6.6 “
CAT 508GR	23.1 x 26	106”	7.1 “
Clark 665	23.1 x 26	114”	7.9 “
Clark 665	18.4 x 24	104”	9.5 “
TreeFarmer C6	18.4 x 34	97”	10.1 “
CAT 518	18.4 x 34	99”	11.2 “

Some of the logging equipment available is too large or heavy to meet MDC requirements in certain vegetation or soil conditions, and some is limited by terrain. Matching the equipment with the site conditions so that minimal damage occurs is critical to the success of watershed silvicultural activities. MDC specifies equipment requirements for each site in its contract bidding. This includes machine width and ground pressure limits, as well as specific equipment requirements (e.g., forwarders). While each site has unique conditions that require the experienced judgement of the forester to predict impacts, ground pressures are generally limited to 8 pounds per square inch or less on soils that are less well-drained (Types 4 and 5 - see Section 2.2.2). Machine widths are limited in intermediate cuttings of dense, unthinned stands with moderate topography, most typically to around 8.5 feet (102”).

T. Kyker-Snowman

Mechanical feller

An example of a “preferred logging system,” that accomplishes MDC goals under difficult conditions is a small feller-processor and forwarder combination, used for thinning dense pine plantations on a variety of soil conditions. Both machines are able to work in these conditions with minimal root, stem, crown, or soil damage. In addition, these machines can successfully work around walls and foundations and do not require a landing, as logs are stacked on the roadside. This combination can also work in previously thinned stands that have an understory of young pines, with minimal damage to the young growth.

The feller-processor is limited to stable ground conditions (few rocks and gentle slopes) and trees less than 16” DBH. In older multi-aged stands where the trees are much larger, hand felling is necessary.

Multi-aged stands will always have many more stems/acre than the present even-aged stands and consequently are more difficult to work in without damaging residual trees. A combination of a winching machine and forwarder works well in multi-aged stands. This logging system addresses the problem of damage to the residual trees associated with long skid roads.

Table 25 summarizes some of the Division's effort to match equipment and logging systems with site conditions. The methods listed in Table 25 are taken from Table 23.

TABLE 25. HARVESTING METHODS/EQUIPMENT USED IN VARIOUS SOIL/TERRAIN COMBINATIONS

	Excessively drained soils	Well-drained thin soils	Well-drained thick soils	Moderately well-drained soils	Poorly to very poorly drained soils
Level to 10% grade	Methods 1-8	Methods 1-8	Methods 1-8	Methods 1-8 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	Generally not worked with machines
11-20% grades	Methods 2-6	Methods 2-6	Methods 2-6	Methods 2-6 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	NA
Slopes greater than 20%	Method 2	Method 2	Method 2	NA	NA

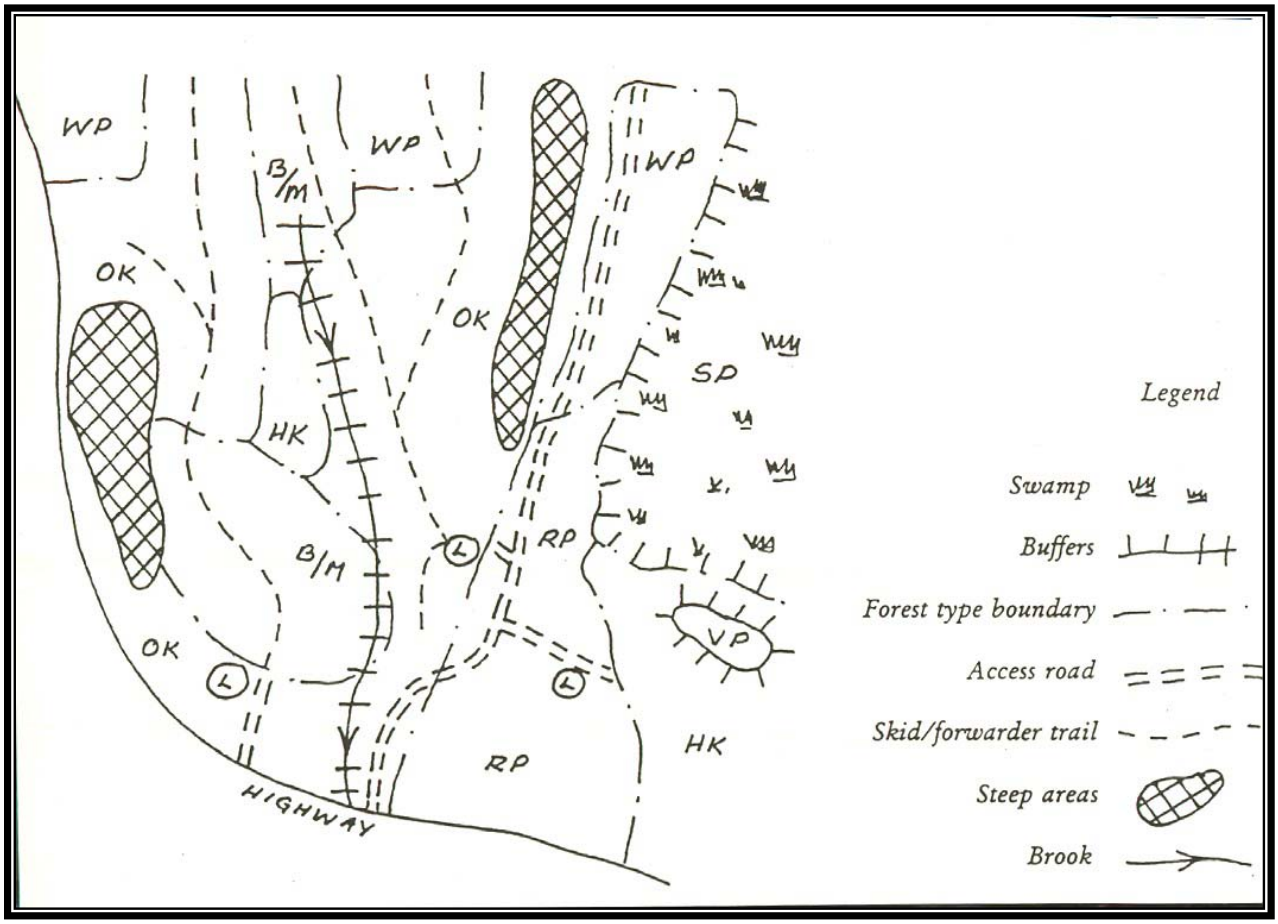
5.2.2.4 Silvicultural Planning

Silvicultural plans have to address present and future cutting practices, landscape aesthetics, cultural resources, wildlife resources, wetlands, and rare or endangered species. While the protection of non-tree resources is of particular concern, the most difficult aspect of planning concerns the maintenance of multi-age stands of trees. These stands have great numbers of trees, especially seedlings, saplings, and poles that are more easily damaged than larger trees. The positioning of permanent logging roads, landings, and small and large group cuts is crucial to the long-term success of silviculture. Logging operation success is dependent upon careful advance planning (see Figure 7 for an example of silvicultural planning).

T. Kyker-Snowman

Well-planned harvest

FIGURE 7. HYPOTHETICAL EXAMPLE OF SILVICULTURAL PLANNING



This approximately 200 acre area of MDC forest contains separate stands of white pine (WP), hemlock (HK), birch/maple (B/M), oak (OK), spruce (SP), and planted red pine (RP). A fire in 1957 severely burned the lower 1/3 of the area, and the red pine was planted shortly after this fire. The topography and hydrography of the area include large areas of well-drained sandy soils, but also several small steep areas, a year-round brook, a swamp, and a vernal pool (VP). These areas are delineated with buffers where required. Work within these areas is restricted; steep areas and muck soils are not worked, and buffers are only worked on frozen or dry ground. Fairy shrimp and mole salamander eggs have been found in the vernal pool, verifying its importance to wildlife. No work is proposed adjacent to this pool.

Except for the steep and wet areas, all the stands have received preparatory cuttings within the past 25 years, and the understory has developed in response. Additional work in this area will release advance regeneration by removing patches of overstory trees averaging 1 acre in size. Where understory species diversity is limited, further preparatory cuttings will occur, as well as enrichment plantings of appropriate species. Primary access is across the permanent road shown by a double dashed line. Single dashed lines are skidder and forwarder roads that have been used in the past and seeded and drained to prevent erosion. Landings are designated by a circled L, and represent areas used in the past and maintained as wildlife openings between operations. These roads and landings will be used again in current operations, and then returned to grass. There is evidence that the landings have been used between operations by wild turkey.

5.2.2.5 Operator Workmanship

Operator workmanship is one of the most crucial and variable factors in forestry operations because good planning and preparation can be negated if operators perform poorly. Most loggers are paid on a piecework basis. Their paycheck does not always relate to how hard or how carefully they worked, but on the amount of wood that gets to the mill. However, the Division maintains tight control over loggers working on the watersheds, and exercises its right to remove operators who fail to adhere to contract standards. It is important that foresters and loggers develop mutual respect that is based upon a shared commitment to the sustainable stewardship of the land.

5.2.2.6 Filter Strips

Filter strips are vegetated borders along streams, rivers, or water bodies (including vernal pools) and represent the final opportunity to prevent transport of sediment or nutrients into streams or reservoirs from nearby roads or landings. When roads and landings are near water resources, filter strips are given special attention. Chapter 132 (Forest Cutting Practices regulations) requires a 50 foot filter strip, in which cutting is limited to 50% of the basal area and machinery is generally not allowed (exceptions include stream crossings).

Chapter 132 regulations require increasing the filter strip based upon slope conditions and along Outstanding Resource Waters (protected public water supplies) and their tributaries (excluding Vernal Pools and bordering vegetated wetlands), streams that are 25 feet or more from bank to bank, ponds of 10 acres or greater, and designated scenic rivers. The Division meets these requirements and also increases the filter strip, based on both slopes and soils, for other areas not included in the definitions above. For example, on moderately and poorly drained soils the filter strip is increased 40 feet for each 10% increment of slope angle above 10%. On well-drained outwash and till soils the filter strip is increased 40 feet for each 10% increase in slope angle above 20%. Equipment may enter the filter strip in limited cases where streams must be crossed (see Section 5.2.4.1.4).

5.2.2.7 Buffer Strip

Buffer strips are retained and managed for aesthetic purposes along the edges of highways and public roads. Chapter 132 requires that within this strip, no more than 50% of the basal area can be cut at any one time and that no additional trees can be cut for five years. Buffer strips will be 50 feet except along designated scenic roads, where Chapter 132 requires them to be 100 feet in width.

5.2.2.8 Wetlands

The Division's forest management operations will comply with all the requirements of the Wetlands Protection Act, MGL Ch. 131 s 40, and the Forest Cutting Practices Act MGL Ch. 132 s 40-50 for cutting in wetlands (including bordering vegetated wetlands and freshwater wetlands as defined in the most current revision of Ch. 131 and 310 CMR 10.00, and as these are revised). Generally, activities that are not conducted under a Ch. 132 Forest Cutting Plan but will alter wetland resource areas (which include a 100 foot "buffer zone" beyond the water or the bordering vegetated wetland), are subject to approval through the filing of a Notice of Intent with the local conservation commission.

T. Kyker-Snowman

Vernal pool

All of the Division's silvicultural activities that involve wetland resources are conducted under a Chapter 132 cutting plan, and therefore are exempt from Chapter 131 procedures, with the exception of limited amounts of work that does not include harvesting, including planting, pruning, and pre-commercial thinning and maintenance of boundaries and fire breaks. All of these latter activities are defined as "normal maintenance of land in agricultural use" by Chapter 131, and are therefore exempt from its filing procedures.

Chapter 132 requires a 50 foot filter strip along all water bodies and Certified Vernal Pools (see section 5.2.2.6. above and 5.2.2.9 below), but allows harvesting in wetland areas provided that no more than 50% of the basal area is cut and the ground is only traveled by machinery when it will support that machinery (when it is frozen or dry). In addition, the Division does not allow machinery within low, flat wetland forest with deep muck soils that are seasonally flooded, even though statewide regulations allow work in some of these areas during frozen or dry conditions. Most of the muck soils on Division lands at Wachusett are included within the designated wetlands on the watershed. The Division has identified and mapped approximately 1,630 acres of wetlands within the Wachusett property, which are avoided when lot boundaries are drawn for proposed annual silvicultural operations. The Division also adheres to the statewide recommended practices for protection of vernal pools, including a 50 foot shade zone and a 200 foot buffer (see Figure 8).

5.2.2.9 Logging Practices

A primary purpose of CMPs is to prevent or minimize the movement of soil to the water resource. During a logging operation, this is most likely to occur on a landing or skid/forwarder road. In these areas, the humus layer is sometimes lost and the soils may be temporarily compacted and channelized so that water will flow over the surface instead of passing through the soil. If the road is unwisely placed on a continuous slope, rainwater will increase in volume and velocity as it travels down-slope, scouring the path, removing soil, and creating a gully. If the road connects with a stream, the suspended soil may be carried much further. The result of careless logging practices can be erosion, increased stream turbidity levels, and deposition of the eroded materials downstream.

Logging practices and the human behavior necessary to avoid environmental degradation during logging are discussed in the following sections. A cutting plan still relies upon the judgement and common sense of the logger and forester to make the right decisions in order to protect the land and associated resources.

T. Kyker-Snowman

A well-organized log landing

FIGURE 8. TIMBER HARVESTING GUIDELINES NEAR VERNAL POOLS.

Adapted from guidelines that were cooperatively developed by foresters and wildlife biologists in Massachusetts.

Vernal pools provide critical habitat for a number of amphibians and invertebrates, some of which breed only in these unique ecosystems, and/or may be rare, threatened or endangered species. Although vernal pools may only hold water for a period in the spring, the most important protective measure is learning to recognize these pool locations, even in the dry season. Foresters can then incorporate the guidelines below in their plans to ensure that these habitats thrive.

Vernal Pool and Depression — *No activity*

Objective 1: Maintain the physical integrity of the pool depression and its ability to hold seasonal water.

1. Keep heavy equipment out of the pool depression at all times of the year. Rutting here could cause the water to drain too early, stranding amphibian eggs before they hatch. Compaction could alter water flow and harm eggs and/or larvae buried in leaf litter at the bottom of the depression.
2. Prevent sedimentation from nearby areas of disturbed soil, so as not to disrupt the pool's breeding environment.
3. Keep tops and slash out of the pool depression. Although amphibians often use twigs up to an inch in diameter to attach their eggs, branches should not be added, nor existing branches removed. If an occasional top lands in the pool depression leave it only if it falls in during the breeding season and its removal would disturb newly laid eggs or hatched salamanders.

Shade Zone — *50 foot buffer around pool edge*

Objective 2: Keep a shaded condition in this 50-ft. wide buffer around the pool depression. Amphibians require that the temperature and relativity humidity at the soil surface be cool and moist.

1. Light, partial cuts that can maintain this microclimate are acceptable; clear cuts are not.
2. Understory vegetation such as mountain laurel, hemlock, advance regeneration or vigorous hardwood sprouts after a harvest will help to maintain this condition. Avoid leaving only trees with small or damaged tops, or dead and dying trees.

Objective 3: Minimize disturbance of the forest floor.

1. Operate in this area when the ground is frozen and covered with snow, whenever possible. When operations must be scheduled in dry seasons, keep equipment 50 feet away from the pool depression and winch out logs.
2. Avoid operating during muddy conditions that would create ruts deeper than 6 inches. Ruts can be an impediment to migrating salamanders, some of which are known to use the same vernal pools and migratory routes for 15 to 20 years.
3. Minimize disturbance of the leaf litter and mineral soil that insulate the ground and create proper moisture and temperature conditions for amphibian migrations.

Low Ground Disturbance Zone — *50-200 feet from pool edge*

Objective 4: As above, minimize disturbance of the forest floor in this area.

1. Operate equipment in this area when the ground is frozen or covered with snow, whenever possible.
2. Follow 2 and 3 from objective 3 above.
3. Locate landings and heavily used skid roads outside of this area. Be sure any water diversion structures associated with skid trails and roads do not connect to or cause sedimentation in the shaded zone or the vernal pool itself.

5.2.2.9.1 Landings

When determining placement and layout of landings, their size and number are minimized and they are located on soils that will support the logging equipment. Landings are permanent sites and are placed on level and well-drained ground whenever possible. Frozen soils are desirable because they support heavy trucks, but these conditions cannot be assumed to occur for more than a month or two each year. When located on moderately drained soils, landings are constructed with natural and/or man-made materials that prevent rutting and maintain a workable surface. This generally includes the use of crushed gravel, which allows water infiltration and supports heavy equipment, and may also include the use of "geo-textiles," woven road construction fabrics that prevent mixing of gravel with the soils below. Landings will not be accessed by skidder or forwarder roads that direct water into the landing. An effective barrier is maintained between the landing and access road (road ditch, hay bales, etc.) and landings are required to be smoothed and seeded after use.

5.2.2.9.2 Skid Roads

Skid roads are designed to be reused and are therefore located on soils that can support the skidder, such as well-drained gravel or well-to-moderately-drained stony till soils. Some soils, regardless of their drainage capacity, are wet in the spring, early summer, and late fall and harvesting must be scheduled for dry or frozen conditions. Skid roads are cut out before use and limbs left in the road to protect the soil. Skid roads are relatively straight to avoid damaging roadside tree stems and roots, but they are not allowed to carry water for more than 100 feet. Continuous grades are deliberately interrupted to divert rainwater off the road. Most skid road grades are less than 10%, but in some cases, climbing grades may reach a maximum of 20%. These steeper climbing grades are limited to 200 continuous feet. Downhill skidding grades are allowed up to 30% but for no more than 200 feet on grades greater than 20%. On skidding grades greater than 20%, which are not protected by frozen ground or snow cover, tree branches will be put on the road and other erosion-control measures taken as necessary.

Skidding distances are minimized to prevent excessive wear to roads unless frozen ground, snow, or rocks protect them. Skidder width and weight requirements are tailored to site conditions. The Division has rated many commercially available skidders by taking into account their horse power, weight, load capacity, tire size, and width to determine their suitability for logging on water supply watersheds (see Table 24 for examples). Skidder width ranges from 85-114 inches and loaded ground pressures range from 5-11 lbs/sq. inch. Typically, machines with loaded ground pressures of 8 lbs/sq. inch or less and widths of 102" or less are allowed on MDC watersheds. Skidding is stopped when rains or thaws make the soils unable to support skidders.

At the end of the logging operation or when work is suspended, skid roads are stabilized to prevent erosion. The construction of water bars accomplishes this task. On slopes greater than 10%, water bars are spaced every 50 feet and on slopes less than 10%, they are spaced every 100 feet. It is sometimes difficult to regularly space water bars due to rocky conditions and lack of places to discharge water, so spacing may vary. Water bars are designed to meet two criteria:

- They must angle across and down the road to create a 3-5% pitch.
- They must discharge water to an area that drains away from the road.

A skidder can usually be used to construct water bars unless the soils are very rocky or ledgy. In rocky soils, they may have to be dug by hand. They do not have to be more than 6-8 inches deep, including the

berm, unless they have to deflect more than the overland flow off skid roads (in which case depths are doubled). After completion of logging, water bars on skid roads are seeded during the growing season.

5.2.2.9.3 Forwarder Roads

Forwarder roads are located on soils that can support these machines. The layout of forwarder roads is more flexible than for skid roads because forwarders do not require straight roads. Forwarder roads can pass through the forest avoiding soft soils, trees, and sloping ground. Forwarder roads usually have less than a 5% slope with an occasional grade up to 10% for a maximum of 100 feet. Forwarder roads sometimes require rough preliminary grading to remove stumps and rocks. Forwarders were originally designed to stay on the road and pick up logs brought to the road by a skidder, but they also replace skidders when soil and/or vegetation conditions and cultural features cannot accommodate skid roads and skidder landings. In operations that combine skidders and forwarders, skidders operate the sloping and rough ground for distances of less than 1,000 feet, while forwarders operate on the more level terrain and handle long hauling distances. Water bar requirements for forwarder roads are the same as for skid roads.

5.2.2.9.4 Stream Crossings

Stream crossings are usually avoidable on MDC watershed properties. When streams must be crossed, frozen conditions are favored whenever possible. These conditions not only protect the actual crossing, but also protect the approach and limit the amount of soil carried in machine tires or on skidded logs.

Portable bridging is used to cross all streams with a continuous flow. This bridging consists of either pre-fabricated sections transported to the site (the Division has constructed portable bridge sections for use by private contractors), or site-constructed bridging. Past studies (Thompson and Kyker-Snowman 1989) have shown that machine placement and removal of crossing mitigation can move substantial sediments into the stream, especially where banks are steep or unstable. Therefore, it may be preferable in some conditions to construct mitigation on-site and without machinery. In either case, the bridging will be designed and constructed so as to prevent degradation of stream water measured downstream of the logging activity before, during, and after that activity.

Correct siting of crossing locations is important in order to avoid soft soils that the machine may carry onto the bridge and into the water. Chapter 132 requires that all crossings be marked with paint or flagging and carefully mapped prior to filing of a cutting plan. All crossings are made at right angles to the streamflow. If frozen conditions are not available, then banks and adjacent soils are protected with tops of trees, poles, or other suitable material. In all crossings, any mitigation that involves structures that obstruct streamflow is designed and installed to accommodate the 25-year stormflow for the upgrade drainage. All temporary crossing construction is removed at the completion of the operation, and the site stabilized. Division foresters supervise the design, construction, placement, and removal of bridging or other mitigation and the proper protection of approaches, prior to the commencement of logging on the site.

Crossings of small, intermittent streams subject to MGL Ch. 131/132 protection (those portions downstream from the highest bog, swamp, wet meadow, or marsh in the drainage) are mitigated to prevent measurable downstream water quality degradation when these streams are flowing. These streams are only crossed without mitigation during frozen or dry conditions (when they are not flowing). No intermittent stream crossing will be allowed that would result in rutting or disruption of stream bank integrity. Chapter 132 further requires that all streams, including intermittent streams downstream of the

highest wetland, within 1000 feet of the reservoir high water mark must be crossed with portable bridging. Division foresters will monitor all unbridged crossings frequently, and discontinue or mitigate them if conditions deteriorate and downstream water quality is threatened.

In the past MDC has crossed streams on a very limited basis. For example, from 1978 to 1990, the Division conducted 130 logging operations on the Quabbin and Ware River watersheds that involved 12 stream crossings (7 were across existing culverts, two were mitigated with DEM-approved techniques, and three were crossings of intermittent streams in dry or frozen conditions).

Table 26 outlines the various stream-crossing situations encountered on Division watersheds and level of protection these crossings are given.

C. Read

Skidder on a temporary bridge

TABLE 26. PROTECTION MEASURES APPLIED TO VARIOUS STREAM CROSSING SITUATIONS

	Level of Protection		
Type of Crossing Situation	CMPs Only	Mitigate	Bridge
Intermittent stream, above the highest wetland in the drainage.	√		
Intermittent stream, downstream of highest wetland, when not flowing; crossing further than 1,000 feet from reservoir high water mark.	√		
Intermittent stream, downstream of highest wetland; crossing further than 1,000 feet from reservoir high water mark; when flowing.		√	
Any intermittent stream with unstable banks/approach; regardless of flow conditions.		√	
Intermittent stream, downstream of highest wetland, crossing within 1,000 feet of reservoir high water mark; regardless of flow conditions.			√
Continuously flowing stream.			√

"Wetland" for the chart above refers to bogs, swamps, wet meadows, and marshes. "Mitigate" includes use of poles, brush, or slabs placed in or beside a small stream to minimize equipment impacts on bank or streambed integrity. "Bridge" includes installed or site-built structures that are above the stream profile and capable of keeping all equipment and harvested products out of the profile.

5.2.2.10 Pollution Control

This section describes methods for control of petroleum product spills, human waste, and the disposal of rubbish generated by loggers and logging machinery maintenance.

Petroleum products: All machines are inspected by Division foresters for leaks prior to arrival and for the duration of their stay on the watershed. Checks are made of all hydraulic components, fuel tanks and lines, engine, transmission and axles. Trucks, forwarders, skidders and other equipment that carry petroleum products must have a minimum of 6 petroleum-absorbent pads (3'x 3') on the machine. Immediate action to contain and stop any petroleum spills followed by prompt notification of the forester is required. The forester in turn contacts MDC Environmental Quality personnel.

All petroleum products that are not in machine storage are stored in safe durable containers and removed from the watershed at the completion of each day. Petroleum storage is only allowed in tanks designed, manufactured, inspected, and certified for commercial use. No re-fueling or servicing is allowed within the 50 foot filter strip along water bodies or within 25 feet of any wetland.

Human waste: Deposition of human solid waste is not allowed on the watershed. Contract specifications require the use of a portable bathroom facility (a minimum of a "Coleman" chemical toilet). The only exception to this policy will be the use of existing sanitary facilities on the watershed, which include those installed for recreational access.

Rubbish: All waste material, including parts, packaging, lubricants, garbage, sandwich wrappers, and other litter must be stored in appropriate containers and removed daily from the watershed.

5.2.2.11 Fire Prevention

Fire prevention concerns both the forest and machinery. MGL Ch. 48, s. 16, a.k.a. the "Slash Law," adequately deals with the disposal of slash along boundaries, water bodies, wetlands, highways, roads and utility right-of-ways. Slash is not allowed within 25' of any stream, river, pond or reservoir. This law is also the Division standard.

Machine fires can spread to forest fires and cause water and soil pollution. Keeping a leak-free, well-maintained machine and having the proper fire extinguishers on the machine can prevent damaging machine fires. All machines are inspected for proper fire extinguisher and spark arresters by a Division forester before entering the site.

5.2.2.12 Residual Vegetation

Avoiding damage to roots, stems, and crowns of understory and overstory vegetation is essential in maintaining a protection forest. Damage can occur from unskilled tree felling, skidding, forwarding and the development of skid/forwarder roads. Skilled loggers and foresters can prevent most damage if the proper logging system is used. Division contracts include the right to suspend operations due to operator inexperience or negligence.

5.2.2.13 Cultural Resource Protection

The protection of cultural resources fits well with watershed management because they both require low-impact logging systems. For example, small versatile equipment can reduce soil compaction and work around walls and foundations without damage. In many locations, there are no places for a landing due to cultural sites or poor soil conditions. Forwarders mitigate this problem by stacking logs on the roadside. The "preferred logging system" in these situations is a combination of cutting, lifting, or winching trees out, and forwarding them to an appropriate landing to meet cultural resource protection objectives (see Section 5.6.1.3 for a more detailed discussion on this subject).

5.2.2.14 Aesthetics

Aesthetics can be affected by all of the practices described in the above sections, and are the demonstration of workmanship quality. The maintenance of aesthetics reflects how the logger feels about his work and about the land on which he is working. This perspective cannot be forced, but it can be encouraged and learned. When work is done correctly it is not conspicuous, but when it is done carelessly, it is obvious to all. These are public lands and the public regularly passes through them either along public roads or on roads within the watersheds. Attention to aesthetics is important everywhere, but most important along traveled ways. All slash and debris from fallen trees is kept 20' back from the road's edge or on the backside of a bordering stone wall. Landings are cleaned of unmerchantable tree debris. Care is taken to maintain large roadside trees and to promote replacement trees.

5.2.3 Control of Harvest Operations Through Timber Sale Permit

5.2.3.1 Introduction

In conducting silvicultural operations that require the removal of forest products from the forest, Division policy is to protect watershed resources such as water quality, soils, residual trees, and cultural resources. Both the timber sale contract, discussed below, and the Conservation Management Practices presented in the preceding section address these concerns. In general, the timber sale contract specifies the performance standards, whereas the CMPs explain how these contract specifications are met.

The Contract consists of written specifications, pages detailing the forest products offered for sale, maps delineating the sale area, and a proposal page where a bid for the timber is entered and signed. The written specifications deal most directly with protecting watershed resources. Specifications consist of five parts: a.) Contractual Specifications, b.) Water Quality Specifications, c.) Logging Specifications, d.) Equipment Specifications and e.) Bidding and Bond Specifications. Parts b., c., and d. pertain to protecting watershed resources.

5.2.3.2 Water Quality Specifications

These specifications are primarily concerned with petroleum leaks and spills and control of human waste. Petroleum products are required to be kept in suitable containers and removed from the work site each day, unless stored in tanks designed for fuel, such as those on the logging equipment. Oil absorbent pads and blankets are required on site and with all equipment, in order to intercept and immediately control a petroleum spill. All associated refuse from maintenance and repair is required to

be stored in appropriate containers and removed from Commission lands as soon as possible. Human waste is required to be deposited in Division toilets or toilets supplied by the operator.

5.2.3.3 Logging Specifications

Logging specifications are concerned primarily with the process of cutting trees and removing forest products from the forest. MDC timber harvesting contracts specify conditions for lopping slash to enhance decomposition and reduce fire hazards. Specifications are described for keeping slash out of streams and back from access roads. The penalty for cutting unmarked trees is set at three times the value of the tree. Utilization standards (maximum stem diameters to be left unharvested) are specified in each contract in order to limit slash. There are also specifications to limit damage to residual trees and soils, especially in the felling and removal of forest products. Locations for logging roads and landings are determined by the forester; the contract specifies the condition in which these areas must be left at the completion of the operation. The contract makes it clear that the logging operation may be suspended due to wet or extremely dry conditions, at the forester's discretion.

5.2.3.4 Equipment Specifications

These specifications limit the size of skidders and other equipment to minimize soil compaction and rutting and to minimize physical damage to residual trees and cultural resources. These specifications may require specific equipment due to the conditions of the lot. For instance, where it is difficult to place straight skid trails, or where dense regeneration is present, the forester may specify that a forwarder must be used and that skidders are not allowed. Where hauling distances to a truck landing are long, but the lot itself requires skidding, the forester may require that both pieces of equipment must be used. The Division also may require a tracked feller-buncher-processor on lots that have sensitive cultural resources requiring specialized tree removal, on soils that cannot support heavy equipment, or in stands with heavy forest stocking that cannot be thinned properly with standard equipment.

5.2.4 Internal Review and Monitoring of Forest Management Operations

The key to the proper protection and management of the resources under the care and control of the Division is its staff, and the care and expertise they bring to their work. Because the foresters walk each acre of land on which forest management occurs, the management controls enforced by this staff are of paramount importance. As the on-the ground implementers of the Division's land management plans and policies, the foresters' knowledge of, and sensitivity to the various aspects of the watershed management plan have a direct bearing on the ultimate success of the program. However, it is impossible for any one individual to assimilate all aspects of the diversity of knowledge in the evolving fields of natural and cultural resource management. Therefore, the second key to implementing sensitive management is in-house review by specialists in the various key disciplines of study in natural and cultural resources, and effective communication between these specialists and the forest managers.

Within the Division, these supporting disciplines include wildlife biology, forest planning, water quality and environmental engineering, civil engineering, and cultural resource protection. Experts available outside MDC include rare species botanists and zoologists (Massachusetts Natural Heritage and Endangered Species Program) and cultural resources specialists (Massachusetts Historic Commission). The Division also has available a wide variety of experts conducting academic research on the watersheds at any given time, in part because of the research value of the resources under the Division's care and control. These professionals, and interested non-professionals who spend time studying and exploring the

watersheds, contribute invaluable observations that complement the Division's understanding of its watershed resources.

To efficiently and effectively coordinate and focus this collective knowledge towards the improved protection of the water supply and other natural and cultural resources, the Division has developed the following procedure for the annual review of all MDC forest management activities on the Wachusett Reservoir watershed. These reviews are in addition to the general guidelines for cultural and wildlife resource protection.

- Each December, the Division's foresters compile a plan of all proposed forest management that could occur during the next fiscal year (July-June). The only operations not included are emergency salvage after natural events. Each January, the foresters carefully map and describe the boundaries of each planned operation so that they are readily distinguishable on the ground (where boundaries are not easy to describe, they are marked with flagging). These outer boundaries may include internal areas where logging is restricted (vernal pools, stream filter strips, etc).

- After mapping the areas where forest management is proposed, the foresters submit site maps and complete forms describing the proposed silviculture in detail to the Division Natural Resource Section. Natural Resources staff digitize the maps of the planned operations, which include proximal wetlands and previously identified critical cultural and wildlife sites, prepare area summaries of these operations, and check the overall consistency of the operations with management plan silvicultural and resource protection objectives. After reviewing the proposed operations, Natural Resources then forwards copies to the watershed Superintendent, the MDC Chief Archaeologist, and the Division's wildlife biologist.

- In 1986, 1990, and 1994 consultants compiled cultural resource maps for MDC/DWM watershed properties. These maps denote known and likely historic sites. This identification process has not yet occurred for the Wachusett Reservoir watershed, although a proposal is being drafted at the time this plan was written. Once these resources are identified, and where forest management is planned for areas containing or likely to contain cultural resources, the Chief Archaeologist will identify types of activity that could damage these resources, such as soil compaction or disruption of existing structures such as walls or foundations. The Chief Archaeologist may also make recommendations for removing trees that threaten existing historic structures, and identifies areas of high, moderate, or low probability of containing prehistoric occupation sites. With these concerns in hand, the foresters modify timber-harvesting approaches as needed to protect these resources.

- Each spring, the Division's wildlife biologist reviews the planned forest management operations. Where necessary, the wildlife specialist conducts site examinations. Landscape level wildlife changes over long time spans will also be tracked using an evolving set of techniques. Local knowledge of state rare, endangered, and threatened species is referenced, as well as the location of any critical or important habitat features in the wildlife biologist's files. After completion of fieldwork by the wildlife specialist, the foresters are alerted to any potential conflicts between the proposed work and important habitat features, keyed to flagging on the ground where necessary. Specific wildlife Conservation Management Practices are outlined in Section 5.5.2 of this plan.

- In 1995 and 1996, the Division contracted with a professional botanist to review all proposed Division lots for the presence of rare or endangered plant species. The bulk of this plant inventory occurred during May and June, although the botanist made preliminary recommendations pending an additional survey for late flowering species, conducted in August, for a limited number of these operations. See section 2.3.3 for a detailed description of this study. In her final reports, the botanist made specific conservation management recommendations to protect these plant populations.

- Where the review process identifies undesirable potential impacts, the foresters consult with the reviewers to design a practical solution. Once the review process is complete, the foresters lay out and mark the harvesting lots. At this time a Forest Cutting Practices Act (MGL Ch. 132) Cutting Plan is prepared (outlining skid roads and specific site impacts). The Forest Cutting Plan is submitted to the Department of Environmental Management (DEM) and copied to the local Conservation Commission. After the lot has been advertised and awarded to a private contractor, Chapter 132 requires DEM staff to conduct a site visit prior to the start of the operation if wetland resources are involved. These regulations also require that Department of Environmental Management Service Foresters check all cutting plans against the Natural Heritage maps of rare and endangered species habitats and, if they overlap, submit these plans to Natural Heritage for review and comment.

Throughout the active operation, it is the responsibility of the forester in charge to continuously monitor compliance with water quality protection measures. In particular, these include stream crossings and work near wetlands, conditions of skidder and forwarder roads as well as main access roads, equipment maintenance, and the treatment and placement of slash. The Division "Permit to Harvest Forest Products" includes detailed specifications for each harvesting operation. During the operation, the Division reserves the right to suspend the harvesting activity if warrented by weather, soil, or wildlife conditions. Upon completion of silvicultural operations, it is the responsibility of the foresters to check for full compliance with all timber harvest permit specifications prior to the release of the performance bond and filing of final reports.

5.3 Management of Non-Forested MDC Lands

5.3.1 Management Practices for Non-Forested Management

In 1999, Division forestry and wildlife staff performed an intensive survey of all non-forested, non-wetland habitats on MDC land at Wachusett. The following data were collected or calculated for each area:

- Habitat type (Forb dominated, Grass dominated, Shrub dominated,
- Hay field, Gravel pit, Administrative)
- Primary Cover (Forb, Grass, Shrub)
- Secondary Cover (Forb, Grass, Shrub)
- Primary Soil Class (Xeric, Mesic, Hydric)
- Secondary Soil Class (same)
- Slope (<1%, 1-5%, 6-10%, >10%)
- Aspect
- Invasives Present (Yes/No, including a list of species)
- Sub-Basin
- Acres
- General Comments (including the presence of birds that require non-forested habitats)

There are currently 162 uniquely identifiable non-forested management areas totaling 964 acres on MDC lands in the Wachusett watershed (an additional 5 areas totaling 39.6 acres exist on off-watershed MDC lands). This represents 6.3% of the total 15,307 acres of MDC land in the watershed. In comparison, the MassGIS 1992 land use datalayer indicates that on non-MDC land in the watershed, non-forested non-wetland habitat types cover nearly 14% of the land area. Residential areas (generally non-forested) cover an additional 12% of the non-MDC land area.